DRAGNET Cluster Usage

Some non-obvious and DRAGNET hardware and setup specific info on using DRAGNET wrt logins, (fast) network transfers, cluster-wide commands and compute job submission / scheduling via SLURM.

Feel free to extend / improve!

Access and Login

To get an account, get permission from the Dragnet PI: Jason Hessels (`hessels@astron.nl`).
With permission from Jason, ask Teun Grit (`grit@astron.nl`) to add access to DRAGNET (via NIS). If you don't have access to the LOFAR portal, tell him. Idem for the ASTRON portal, i.e. if you are not working for ASTRON.

Having an account, ssh to hostname `dragnet.control.lofar` or easier, just **`dragnet`**, from the LOFAR portal (or tunnel through it):

```
$ ssh USERNAME@dragnet
```

Password-less Login

Within the cluster (or even to it), don't bother typing your password all the time. Passwords make cluster-wide commands a nightmare. Instead, use an ssh key pair:

```
$ ssh-keygen -t rsa  # or copy an existing public key pair to .ssh/
$ cat .ssh/id_rsa.pub >> .ssh/authorized_keys
$ chmod 600 .ssh/authorized_keys
```

(For completeness: Your .ssh/id_rsa contains your private key. Do **not** share it with others. If compromised, asap regenerate the key pair.)

To make login between nodes more reliable, you can disable the ssh host identification verification within DRAGNET. It is overkill within our cluster and if we ever need to reinstall a node, its key fingerprint will then change, causing your (auto-)login to fail until you manually remove the offending entries from `.ssh/known_hosts`.
To disable, add to (or create) your `.ssh/config` file on DRAGNET:

```
NoHostAuthenticationForLocalhost yes

Host dragnet dragnet.control.lofar dragproc dragproc-10g
dragproc.control.lofar dragproc-10g.online.lofar drg?? drg??.control.lofar
drg??-10g drg??-10g.online.lofar drg??-ib drg??-ib.dragnet.infiniband.lofar
StrictHostKeyChecking no
```

Now test if password-less login works by logging in and out to `drg01` without entering a password (this should succeed with no output):

```
ssh drg01 exit
```

Finding Applications

To use most applications conveniently, you need to set or extend environment variables, such as PATH, LD_LIBRARY_PATH, PYTHONPATH, ...

Practical Summary

On DRAGNET add to your .bash_profile e.g.:

```
module add local-user-tools lofar casacore python-casacore
```

or a similar list (python-casacore is also known as pyrap).

Command to print the list to select from:

```
$ modules avail
```

Re-login (or enter the `module add <pkgs>` command by hand) to apply in each login session.

We have found that having `casa` in the module path interferes with certain tasks for some reason (it only adds to PATH(?)). Just run the latest NRAO CASA release using `/usr/local/casa-release/bin/casa` (`casa-release` symlink is updated periodically), or use `casa-release-x.y.z-*` to keep using a specific release.

Using the Environment Modules

The “environment values” is a set of key-value pairs per program, inherited from the program that started it. Each shell has its own copy (so if you change one, others are unaffected). Your environment is copied and adjusted at login. You can further adjust it using .bash_profile (or .profile or .bashrc or ...).

The complete, sorted list (1000s of lines) and (unexported) shell variables can be printed by typing `set`.

Unlike CEP clusters that use the home brew `use <pkg>` command, we use the `module <command> [pkg]` command. Type `module help` for a list of commands.

List of available modules (Apr 2016):

```
$ module avail

------------------------------------------------------------------------
/usr/share/Modules/modulefiles ------------------------------------------
-----------------------------
dot         module-git  module-info modules     null        use.own
```

```
------------------------------------------------------------------------
----- /etc/modulefiles -------------------------------------------------
----------------------------
casa/4.5           casacore/2.0.3     cuda/7.0           local-user-tools
lofar/2.14.0       lofardal/current   python-casacore
casa/current       casacore/current   cuda/current       lofar/2.11.4
lofar/current      mpi/mpich-x86_64   srm/2.6.28
casacore/2.0.1     casarest           karma/1.7.25       lofar/2.12.0
lofardal/2.5.0     mpi/openmpi-x86_64
```

Add latest lofar module to your env:

```
$ module add lofar   # or a specific one e.g. module add lofar/2.12.0
```

Remove module from your env (e.g. if it conflicts with another version you want to use):

```
$ module rm lofar
```

See what adding the `local-user-tools` module does (Apr 2016):

```
$ module show local-user-tools
-------------------------------------------------------------------
/etc/modulefiles/local-user-tools:

module-whatis    Adds tools, libraries and Python modules under /usr/local
to your environment.
  Pulsar tools : dspsr, psrcat, psrdada, pstfits, psrchive, tempo, tempo2,
dedisp, sigproc, ffasearch, ephem, see, clig, ...
  Imaging tools: pyselfcal, losoto, ds9, Duchamp, sagecal, excon, wsclean,
rmsynthesis, ...
prepend-path     PATH /usr/local/bin
prepend-path     LD_LIBRARY_PATH /opt/casacore/lib:/usr/local/lib64 #
casacore-2.0.3 for sagecal, excon, wsclean
prepend-path     PYTHONPATH /usr/local/lib/python2.7/site-packages/
-------------------------------------------------------------------
```

Hostname Hell and Routing Rampage

If you are just running some computations on DRAGNET, skip this section. But if you need fast networking, or are already deep in the slow data transfers and rapid-fire connection errors, here is some info that may save you time wrt the multiple networks and network interfaces. (Or just tell us your needs.)

Hostnames

- dragnet(.control.lofar)
- dragproc(.control.lofar)

- drg01(.control.lofar) - drg23(.control.lofar)

Networks

```
Control/Management network: NODENAME.control.lofar (1 Gb) (all nodes)
10G network:                NODENAME-10g.online.lofar (10 Gb) (all drgXX
nodes and the dragproc node)
Infiniband network (IPoIB): NODENAME-ib.dragnet.infiniband.lofar (56 Gb)
(all drgXX nodes)
```

(There is also a 1 Gb IPMI network.)

Cross-Cluster

When writing scripts that (also) have to work cross-cluster, prefer to use the fully-qualified domainnames (FQDN) (e.g. `drg11-10g.online.lofar` instead of just `drg11`). See `/etc/hosts` on any node for the list.

In most cases, you will use the network as deduced from the destination hostname or IP. Indicate a 10G name to use the 10G network. Idem for infiniband (IPoIB). (Exception: CEP 2, see below.)

Note: Copying large data sets at high bandwidth to/from other clusters (in particular CEP 2) may interfere with running observations as long as CEP 2 is still in use. If you are unsure, ask us. It is ok to use potentially oversubscribed links heavily, but please coordinate with Science Support!

CEP 2

Initiate connections for e.g. data transfers from CEP 2 to HOSTNAME-10g.online.lofar and you will go via 10G.

The reverse, connecting from DRAGNET to CEP 2, by default will connect you via DRAGNET 1G (e.g. for login). To use 10G (e.g. to copy datasets), you need to bind to the local 10G interface name or IP. The program you are using has to support this via e.g. a command-line argument.

Cluster-wide Commands

To run a command over many cluster nodes, use `cexec` (as on CEP2/3), `ansible`, or a shell loop around an ssh/scp command. (First, see the section above on **Password-less Login**.)

- cexec (shell) runs any shell command in parallel. Output is sorted and only appears after all nodes finished. Indexed hostname specification.
- ansible (Python) is easy with simple commands or with Ansible modules to support idempotent changes. Easy integration in Python programs. No sorted output, but node output appears when a node is done. No shell interpretation of commands, which may be a restriction or rather safe. Can run commands in parallel. Tailored for system administration, configuration and deployment.

- shell loop around ssh is most basic and possibly powerful wrt UNIX tools, but tricky wrt escaping, which remote environment values are actually used, and for dealing correctly with filename corner cases. Scripts easily end up shell specific (e.g. bash vs tcsh).

NOTE: be careful with potentially destructive operations like `rm -rf`. Accidents have happened (data loss) on CEP2 with cexec and shell scripts.

C3 Cexec

The Cluster Command and Control (C3) tool suite contains the cexec(1) program that can be used to run commands over many nodes.

Example:

```
$ cexec drg:3-5 "df -h"    # disk usage on the drg04(!), drg05, drg06(!)
nodes
$ cexec dragnet:23 ls      # run ls on dragproc
$ cexec hostname           # hostnames as seen from each cluster node
```

The hostname specifier (2nd optional argument) must contain a ':' and may also be `drg`, which excludes the `dragproc` node. The `dragnet` hostname specifier contains all nodes (incl head node). The `drg` group is without `dragproc`. The head node is never part of the group, though you can explicitly specify it if needed e.g. in scripts. Note that the hostname numbers here specify start and end index (starting at 0!).

Ansible

Ansible is a tool to automate cluster (administration) tasks.

Examples of simple commands:

```
$ ansible alldragnet -a 'df -h'                                  # disk
usage on all nodes
$ ansible proc:workers -f 25 -a 'df -h /data1 /data2'            # disk
usage on dragproc and worker nodes, connect to max 25 nodes at a time
$ ansible workers -f 25 -a 'ls -al /data1/LOBSID /data2/LOBSID'  # list
/data*/LOBSID files on all drg* nodes, connect to max 25 nodes a time
$ ansible drg01:drg17 -a 'ls -l /data1'                          # list
/data1 on drg01 and drg17 (not drg01 till drg17)
```

Apart from hostnames, the following hostname groups are also recognized on DRAGNET: `head`, `proc`, `workers`, `alldragnet`, `all` (last two are the same). The command must be a simple command. It can be the name of an executable shell script if accessible to all hosts, but not a compound shell command with &, &&, pipes or other descriptor redirection (you can of course run the shell with some argument, but then, what's the point of using ansible like that?).

Background: Ansible heavily relies on the idea to specify what you want in terms of the desired situation rather than what to do to get there. Such *idempotent* commands work correctly regardless whether some nodes are already ok or different. To this end ansible has numerous modules to

manipulate system settings in an easy way, but you can also write your own modules (e.g. to reinstall (parts of) a type of node), or so-called *playbooks* to manage configuration and deployment.

For many common system admin related tasks, use an ansible module. Search the Ansible Module Index for more info.

Shell Loop and SSH

Examples:

```
$ for ((i = 1; i <= 10; i++)); do host=$(printf drg%02u $i); ssh $host "df -
h"; done  # disk usage on the drg01-drg10 nodes
$ for host in drg01 drg17; do ssh $host "df -h"; done
# disk usage on drg01 and drg17
```

Be careful with complex commands!

SLURM Job Submission

To utilize the cluster efficiently, we use the SLURM workload manager. This is also supposed to ensure that batch jobs do not interfere with observations that DRAGNET participates in (as in: micromize observation data loss).

Random notes:

- SLURM does not enforce accessing nodes through it; one can access any node via ssh. Depending on the intention and the current workload, that may be fine or less desirable.
- SLURM has a ton of options that we haven't all set up. In particular, atm it does not enforce exclusive access to GPUs via cgroups (although it does set `CUDA_VISIBLE_DEVICES` if you explicitly request GPUs). Once a node is (partially) assigned to your program, your program can in principle use any resource on that node.

Introduction: the trivial stuff

From any DRAGNET node (typically the `dragnet` head node), you can submit compute (or perhaps also separate data transfer) jobs.

Use `srun` to start a task, see output as it is produced, and wait for completion. Use resource options such as –nodes=10 or –tasks=10, and/or –nodelist=drg01 to reserve nodes or CPUs (see below or `man srun` for more info).

```
$ srun --nodes=5 --nodelist=drg01,drg02 ls -l /data1 /data2
dir1 dir2 file1 file2 [...]
```

Use `sbatch` to queue a job to run a supplied batch script with various commands, advanced options, and resource specifications in shell comments (see below). (No need to also use the `screen` command.) Slurm immediately prints the JobId and returns. It redirects stdout and stderr to a slurm-

<JobId>.log file. For simple cases, auto-generate the script using –wrap.

```
$ sbatch --mail-type=END,FAIL --mail-user=your-email-addr@example.com --
wrap="ls -l /data1 /data2"
Submitted batch job <JobId>
```

The `srun` and `sbatch` mostly take the same args, so likely, you want to combine the 2 examples above using `sbatch` and the resource options, or better, supply a simple shell script.
Tip: use absolute path names and $HOME.

Show list of jobs queued:

```
$ squeue
             JOBID PARTITION     NAME     USER ST       TIME  NODES
NODELIST(REASON)
                 9   workers       ls amesfoor CD       0:01      1 drg
```

Show list of recently completed jobs:

```
$ squeue -t COMPLETED
             JOBID PARTITION     NAME     USER ST       TIME  NODES
NODELIST(REASON)
                 9   workers       ls amesfoor CD       0:01      1 drg
```

Show details of a specific job:

```
$ scontrol show job <JobId>
JobId=223058 JobName=wrap
   [<~20 lines of info on status, resources, times, directories, ...>]
```

Show list and state of nodes. When submitting a job, you can indicate one of the partitions listed or a (not necessarily large enough) set of nodes that must be used. Please hesitate indefinitely when trying to submit insane loads to the head partition. :)

```
$ sinfo
PARTITION AVAIL  TIMELIMIT  NODES  STATE NODELIST
workers*     up   infinite     23   idle drg[01-23]
proc         up   infinite      1   idle dragproc
head         up   infinite      1   idle dragnet
```

If you get an error on job submission that there are no resources in the cluster to ever satisfy your job, and you know this is wrong (no typo), you can see with the `sinfo` if there are nodes out of service. (SLURM may remove a node from a partition on misconfiguration or hardware malfunctioning.)

More detail:

```
$ sinfo -o "%10N %8z %8m %40f %10G %C"
NODELIST   S:C:T    MEMORY   FEATURES                                 GRES
CPUS(A/I/O/T)
drg[01-23] 2:8:1    128500   (null)                                   gpu:4
0/368/0/368
dragnet,dr 1+:4+:1+ 31800+   (null)                                   (null)
0/24/0/24
```

where in the last column A = Allocated, I = Idle, O = Other, T = Total

Hints on using more SLURM capabilities

The sbatch(1) command offers to:

- take a user-supplied job (batch) script, not just to start your script, but also to set up a job array or workflow
- have stdout/stderr go to a file
- copy the program (and possibly library and data dependencies) to the to be used nodes
- run the job without blocking your terminal on its completion. This is useful for e.g. substantial processing jobs
- auto-restart on failure (not sure when/how that applies)

Apart from nodes, it is also possible to indicate scheduling constraints on CPU cores, GPUs, memory, or network bandwidth (if we set that up).
Atm, you have to indicate constraints for:

- either number of nodes or CPUs
- number of GPUs, if any needed. If no GPUs are requested, any GPU program will fail. (Btw, this policy is not fully as intended, so if technically it can be improved, we can look into it.)
- if you want to run >1 job on a node at the same time, memory. Just reserve per job: 128500 / NJOBS_PER_NODE. By default, SLURM reserves all the memory of a node, preventing other jobs from running on the same node(s). This may or may not be the intention. (If the intention, better use --exclusive.)

Note that a CPU is to SLURM a hardware resource that the OS can schedule a task on. On DRAGNET it is a CPU core (16 on all nodes, but 4 on the head node). (On typical SLURM installs, it's a hardware thread, but we don't expect to get something out of HyperThreading.)

To indicate a scheduling resource constraint on 2 GPUs, use the –gres option (*gres* stands for *generic resource*):

```
$ srun --gres=gpu:2 -n 1 your_gpu_prog
```

To indicate a list of nodes that must be used (list may be smaller than number of nodes requested). Some examples:

```
$ srun --nodelist=drg02 ls
$ srun --nodelist=drg05-drg07,drg22 -n 8 ls
$ srun --nodelist=./nodelist.txt ls   # with a '/' in the arg value
```

For the moment, see more explanation and examples at
http://hpcf.umbc.edu/how-to-run-programs-on-maya/

Please see the manual pages on srun(1), sbatch(1), salloc(1) and the SLURM website for more info.

SLURM Cluster Management

Some commands I looked up and probably need again another time.

Bring fixed node back to partition from state DOWN to state IDLE (logged in as slurm):

```
$ scontrol update NodeName=drg02 state=idle
```

Users can resume their (list of) job(s) after SLURM found it/they cannot be run (network errors or so) and sets the status to something like 'launch failed, requeued held'. If the range is sparse, slurm prints some errors, but does resume all existing jobs.
This can also be exectured by users for their own jobs.

```
$ scontrol resume 100
$ scontrol resume [1000,2000]
```